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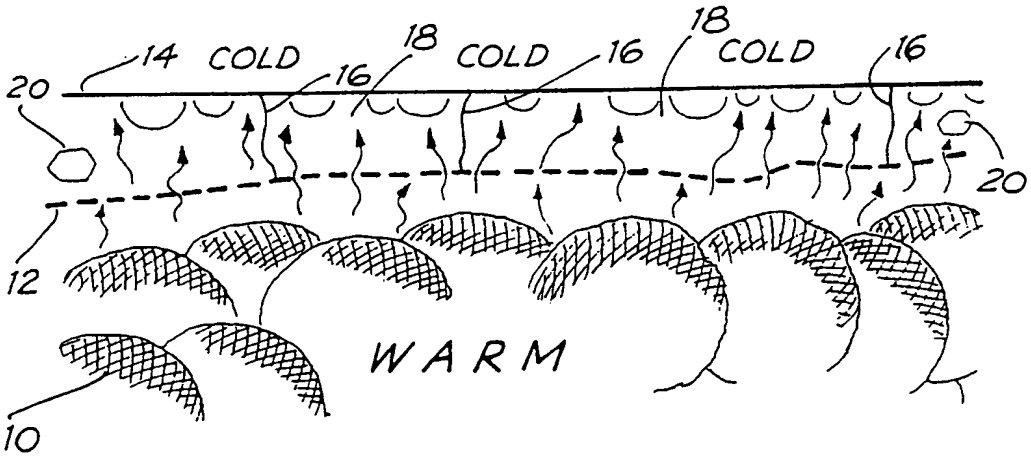
(54) Title: CONDENSATION CONTROL IN HORTICULTURAL PACKAGING



(57) Abstract

The present invention provides a packaging material for use in packaging horticultural produce and to a method of packaging horticultural produce. The packaging material and method of packing of the present invention enables a substantial reduction in the amount of water condensation on the packed produce to be achieved. The packaging material comprises a first sheet which is freely permeable to water but resistant to capillary transfer of liquid water and a second sheet which is impermeable to water vapour and liquid water. There is a space provided between the first and second sheets.

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CONDENSATION CONTROL IN HORTICULTURAL PACKAGING

Field of the Invention

The present invention relates to a packaging material and to a method of packaging horticultural produce. The packaging material and method of packing of the present invention enables a substantial reduction in the amount of water condensation on the packed produce to be achieved.

Background of the Invention

Condensation of water within plastic bags and box liners holding horticultural produce presents a serious problem in transport and storage. The plastic liners and bags are necessary in that they prevent excessive loss of water from produce. Ideally, the relative humidity inside the packaging is kept high, so that little water is lost from the produce and it keeps fresh and turgid. This means that the vapour pressure of the water within the pack is maintained close to the equilibrium vapour pressure of water over the produce.

Produce when packed is usually at a higher temperature than its surrounds in the store. In addition, the produce (fruit, vegetables, cut flowers, potted ornamentals etc.) is living and therefore produces heat as a result of metabolic activity. These two factors result in the temperature of the produce tending to be higher than that of the inside surface of the packing material. This in turn means that the vapour pressure of water over the produce will often exceed the saturation vapour pressure of water at the cooler inside surface of the packing material. Where this occurs, water will condense on the inside surface of the packing material.

Droplets of condensed water tend to coalesce, and collect in corners and at the bottom of the package. As a result, produce in such positions will be wetted. Where wetting occurs, gas exchange between the fruit tissue and the surrounding atmosphere may be impeded. Salts and

nutrients such as sugars and amino acids will also leak from the produce into the water. This resulting extract encourages the growth of microorganisms, which will further consume the oxygen which is already in restricted supply to the respiring produce. Some of these microorganisms are likely to invade the produce and cause rots. As a direct result of fungal growth, and as a secondary response of the plant tissue to infection, the gas ethylene is likely to be evolved. This gas, even at concentrations less than 1 microlitre per litre has a generally deleterious effect on the storage life of many horticultural commodities and can cause off-flavours. Off-flavours may also be produced directly by microorganisms. In addition, contact of a number of fruits such as grapes, plums and blueberries with water results in a loss of bloom from the fruit. This in turn leads to a lower market price for the fruit.

Due to the problems resulting from condensation wetting of horticultural produce, the full benefits of high humidity in packages are not able to be realised. Typically, commodities are not wrapped completely or are wrapped with a water-permeable cover so as to lessen the risk of condensation occurring. This results in part or all of the produce losing excessive amounts of water. Such water stress reduces the life of the commodity and its quality.

One means of avoiding, to some extent, the difficulty of condensate forming within the package is to use a packaging material which has some permeability to water vapour. Examples of such packaging material are disclosed in Australian patent application No. 38079/89, GB1369992 and US 4079152. It is disclosed in US 4079152 and GB 1369992 that a desiccant, preferably within a pouch, is included in the packaging material to absorb any excess condensate. Such packaging, however, does not allow the

full benefits of high humidity in packages to be achieved.

Summary of the Present Invention

In a first aspect the present invention consists in a packaging material for use in packing horticultural produce the packing material comprising a first sheet which is freely permeable to water vapour but resistant to capillary transfer of liquid water, and a second sheet which is impermeable to water vapour and liquid water, the first and second sheets being spaced apart from one another.

In a second aspect the present invention consists in a packaging material comprising a first sheet which is freely permeable to water vapour but resistant to capillary transfer of liquid water, and a second sheet which is impermeable to water vapour and liquid water, the first and second sheets being connected at a number of points over the surface in a manner such that space exists between the first and second sheets.

In a third aspect the present invention consists in a method of packing horticultural produce comprising the steps of:-

(i) wrapping the produce in a first sheet, the first sheet being freely permeable to water vapour but resistant to capillary transfer of liquid water; and

(ii) wrapping the wrapped produce with a second sheet, the second sheet being impermeable to water vapour and liquid water, the wrapping being such that a space exists between the first and second sheets.

In a preferred embodiment of this aspect of the present invention the first and second steps are carried out simultaneously by means of the first sheet and the second sheet being connected at a number of points over the surface of the sheets.

The first sheet is typically composed of hydrophobic polymers such as polyethylene or polypropylene or polymers

which have been rendered hydrophobic by special treatments such as, silicone coating. Such polymers can be made in the form of fibres that can be used to fabricate sheet material. The resulting sheet material may be non-woven or woven. The essential characteristic is that the sheet is freely permeable vapour but resistant to the capillary transfer of liquid water. This resistance to capillary transfer of liquid water is achieved due to the non-wettable (hydrophobic) nature of the sheet material.

A number of such sheet materials that resist the passage of free water but are permeable to water vapour are made by Du Pont from polyethylene under the trade name "TYVEC". A sheet material having similar properties but made from polypropylene fibres is sold by Kimberley Clark under the trade mark "EVOLUTION". At present it is preferred that the first sheet is made from polypropylene fibres, and is preferably the material "EVOLUTION" sold by Kimberley Clark.

The "EVOLUTION" material is made in a number of grades ranging from 16 grams per sq. metre of fabric to 80 grams per sq. metre of fabric, however, it is presently preferred that the first sheet has a weight of 24 grams per sq. metre of material.

The second sheet material may be composed of any number of materials which are impervious to liquid water and water vapour. At present, however, it is preferred that the second sheet comprises a film of polyethylene.

In a preferred embodiment of the present invention the first and second sheets are connected at the number of points by point welding.

In a further preferred embodiment of the present invention a desiccant is provided within, and partly fills, the space between the first and second sheets. This desiccant may be any of a number of such materials well known in the art, however, it is presently preferred

that the desiccant has some humidity buffering capabilities.

A material having such humidity buffering capabilities may be produced by mixing a water-swellable, water-insoluble polymer with a mixture of (1) a non-volatile hydrophilic liquid and (2) water, the polymer being swellable by the mixture. By adjusting the relative portions of (1) and (2) the humidity buffering capabilities of the formulation can be adjusted. The water-swellable polymer may be any of a large number of such materials such as "TERRA-SORB", "AGROSOKE", "IGETAGEL", "SUPER-SORB", "SUPER-SLURPER" and "ALCOSORB". It is presently preferred that the water-swellable polymer is "ALCOSORB AB3S", made by Allied Colloids. It is also preferred that the non-volatile hydrophilic liquid is glycerol. Details regarding humidity buffer formulations can be found in WO91/00316 in the name of the present applicant.

In a further preferred embodiment of the present invention the desiccant is contained in a woven or non-woven cloth which is freely permeable to water vapour and liquid water (hydrophilic cloth).

Detailed Description of the Invention

In order that the nature of the present invention may be more clearly understood, preferred forms thereof will now be described with reference to the accompanying drawings and following examples.

Figure 1 shows schematically the diffusion of water vapour in prior art packing of horticultural produce. In Figure 1, the produce 10 is at a mean temperature higher than that of the storage environment. Living produce has a high water potential and therefore in such a closed environment is surrounded by a relative humidity very close to saturation. Under such conditions, the water vapour pressure depends on the temperature. There is,

therefore, a net diffusion of water symbolised by the arrows in Figure 1 down the gradient of water vapour pressure. This gradient corresponds to the temperature gradient between the produce 10 and the moisture barrier 11. At 11, water condenses as soon as saturation vapour pressure is exceeded. This condensation wets the commodity by physical contact.

Figure 2 shows schematically the diffusion of water vapour using the packing material and method of the present invention. As shown in Figure 2 there is a net diffusion of water, symbolised by the arrows, down the gradient of water vapour pressure from the produce 10 through first sheet 12 to second sheet 14. As the first sheet 12 is permeable to water vapour the passage of water vapour from the produce 10 and subsequent condensation on second sheet 14 is not impeded by first sheet 12. In addition, as shown in Figure 2, the first sheet 12 is connected to second sheet 14 at a number of points indicated generally as 16, leaving space 18 between the first sheet 12 and the second sheet 14. Provided within space 18 is desiccant 20.

Figure 3 illustrates schematically the resistance of the first sheet to the passage of liquid water. Due to its hydrophobicity first sheet 12 is not easily wetted by water, and any condensate will therefore be prevented from wetting the produce 10.

If the second sheet 14 is made of a hydrophobic plastic such as polyethylene, droplets rather than a continuous film of water will be formed. Such droplets tend to coalesce and dribble down the walls to the base of the package, where they can, if desired, be absorbed by capillary action in a desiccant 20. At no point can the liquid water pass back to the produce 10, because it is repelled by the hydrophobic nature of the first sheet 12. Once the condensed water is absorbed by the desiccant 20,

its surface area for re-evaporation will be reduced and its vapour pressure will be reduced below that of pure water. The extent to which this reduction occurs can be controlled by using a humidity buffer as the desiccant. If the external temperature now rises to be temporarily above that of the produce, the likelihood that condensed water can return as vapour to recondense on the cold produce is reduced if such a desiccant is used.

Figures 4 to 6 show results which demonstrate the effectiveness of the packing material and method of packing of the present invention in preventing condensate from wetting packaged produce. These figures contrast the amount of produce wetting using the packing material and method of the present invention with that of the prior art.

In all cases, produce at a temperature of 20°C was hermetically sealed in a bag of low-density polyethylene and the whole pack was then cooled to a temperature of 1°C. This bag of low density polyethylene constituted the second sheet in the method of the present invention. The amount of water on the produce was then determined by wiping the produce with a weighed paper tissue and subtracting its dry weight from the weight following wiping. The amount of water on the packing material was determined by weighing it before and after drying in an oven at 70°C.

In each of these experiments the second sheet comprised a sheet of spun polypropylene having a weight of $24g/m^2$.

Figure 4 shows the results of cooling plums over 23 hours within a sealed polyethylene bag. After cooling, the bags were agitated to redistribute the water. In the prior art packing method (A), the distribution of the recovered condensate was 53% on the fruit surface and 47% on the surface of the polyethylene bag. In the method of

the present invention (B), only 2% was on the fruit whilst 98% remained on the packing material.

Figure 5 shows the results of a similar test, in which nectarines were cooled for 46 hours. In the packing method of the prior art (A), the distribution of the recovered condensate was 73% on the fruit surface and 27% on the surface of the polyethylene bag. Using the method of the present invention (B) only 1% was on the fruit whilst 99% remained on the packing material.

Figure 6 shows the results of cooling cabbage under the same conditions, except the time was increased to 144 hours. In the prior art packing method (A), there was 36% of the condensate on the surface of the cabbage and 64% on the surface of the packing material. Using the method of the present invention (B), only 2% was on the cabbage whilst 98% remained on the packing material.

As can be readily seen from these results, the packing material and packing method of the present invention results in a substantial reduction in the amount of wetting of packed produce.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

CLAIMS:-

1. A packaging material for use in packing horticultural produce, the packaging material comprising a first sheet which is freely permeable to water vapour but resistant to capillary transfer of liquid water; and a second sheet which is impermeable to water vapour and liquid water, the first and second sheets being spaced apart from one another.

2. A packaging material as claimed in claim 1 in which the first and second sheets are connected at a number of points over their surface in a manner such that a space exists between the first and second sheets.

3. A packaging material as claimed in claim 2 in which the first and second sheets are connected by point welding.

4. A packaging material as claimed in any one of claims 1 to 3 in which a desiccant is provided within, and partly fills, the space between the first and second sheets.

5. A packaging material as claimed in claim 4 in which the desiccant is a humidity buffer formulation comprising a water-swellable, water-insoluble polymer and a mixture of (i) a non-volatile hydrophilic liquid and (ii) water; the polymer being swellable by the mixture.

6. A method of packing horticultural produce comprising steps of:-

(i) wrapping the produce in a first sheet, the first sheet being freely permeable to water vapour but resistant to capillary transfer of liquid water; and

(ii) wrapping the wrapped produce within a second sheet, the second sheet being impermeable to water vapour and liquid water, the wrapping being such that a space exists between the first and second sheets.

7. A method as claimed in claim 6 in which the first and second steps are carried out simultaneously by means of the first sheet and the second sheet being connected at a number of points over the surface of the sheets such that

a space exists between the first and second sheets.

8. A method as claimed in claim 7 in which the first and second sheets are connected at a number of points by point welding.

9. A method as claimed in any one of claims 6 to 8 in which a desiccant is provided in, and partly fills, the space between the first and second sheets.

10. A method as claimed in claim 9 in which the desiccant is a humidity buffer formulation, the formulation comprising a water-swellable, water-insoluble polymer and a mixture of (i) a non-volatile hydrophilic liquid and (ii) water; the polymer being swellable by the mixture

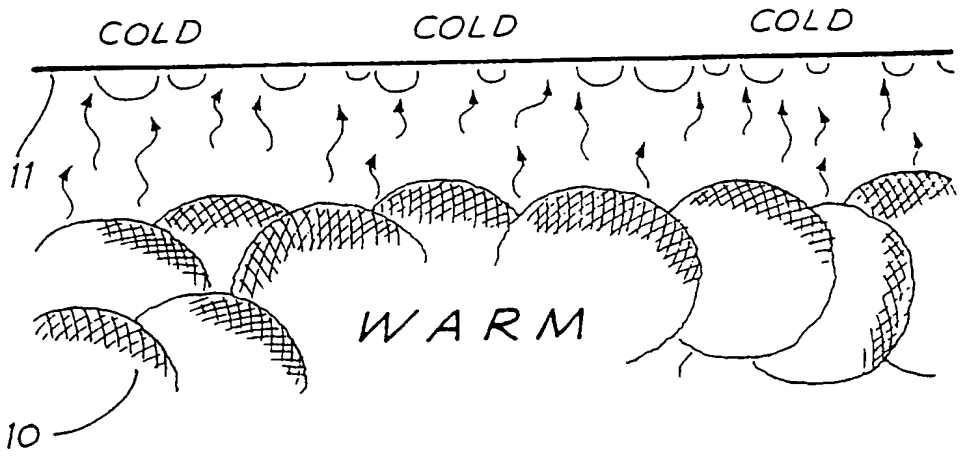

FIG. 1

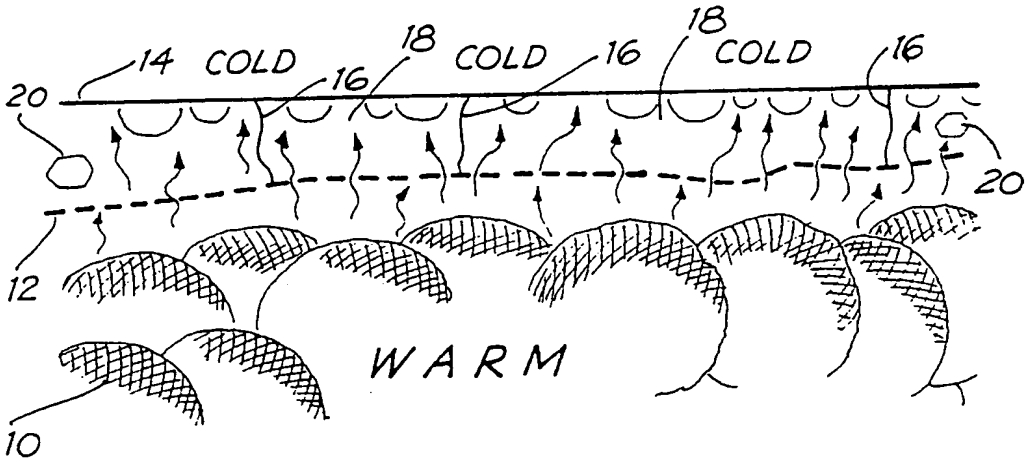

FIG. 2

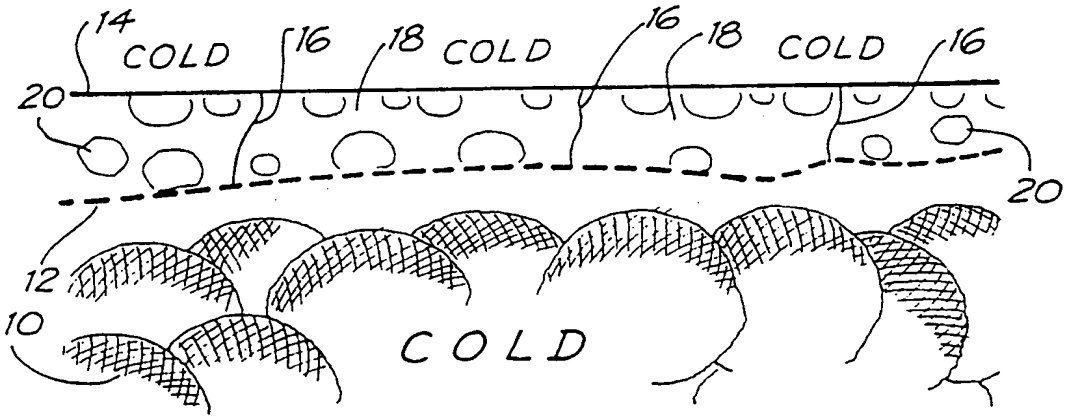

FIG. 3

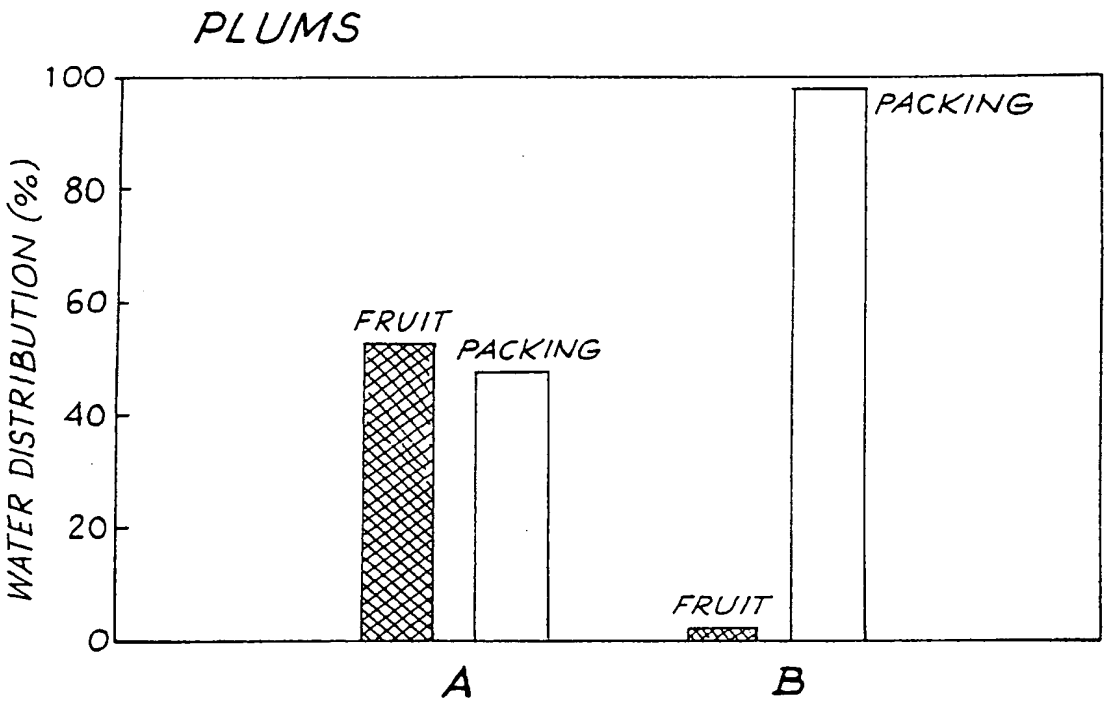
PLUMS
WATER DISTRIBUTION (%)
100
80
60
40
20
0
FRUIT
PACKING
FRUIT
PACKING
A
B

FIG. 4

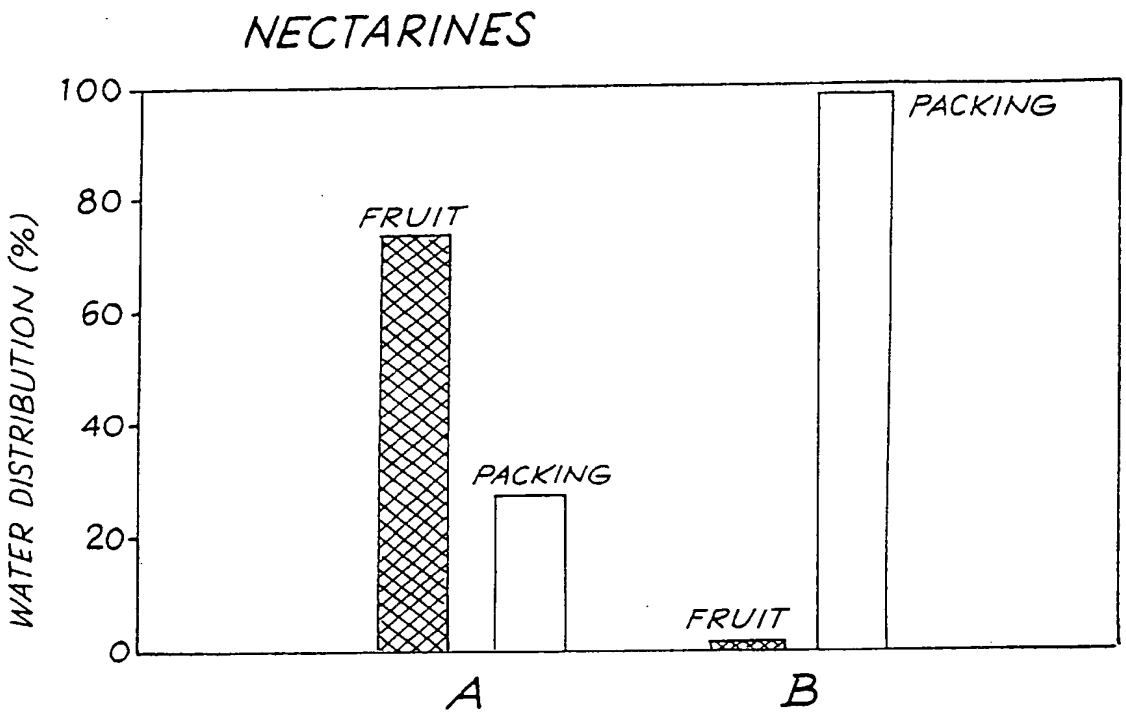
NECTARINES
WATER DISTRIBUTION (%)
100
80
60
40
20
0
FRUIT
PACKING
FRUIT
PACKING
A
B

FIG. 5

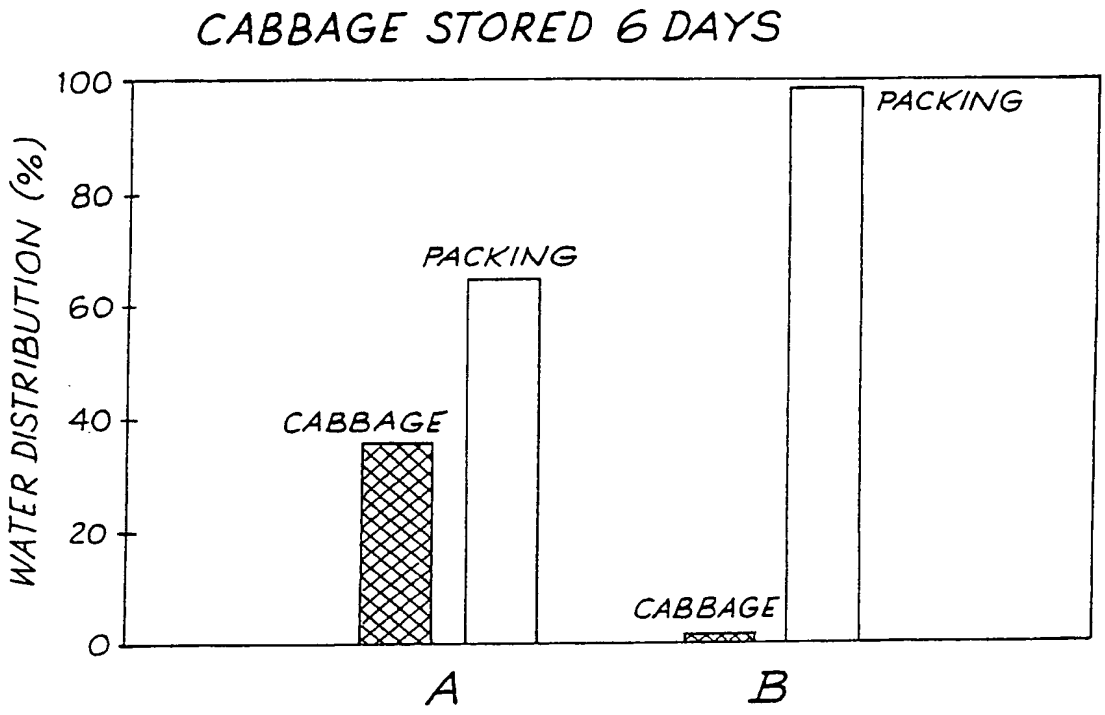
CABBAGE STORED 6 DAYS
WATER DISTRIBUTION (%)
100
80
60
40
20
0
CABBAGE
PACKING
CABBAGE
PACKING
A
B

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 91/00145

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[5] B32B 7/02, 5/02, 27/32; B65B 55/00, 61/22

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	B32B 7/02, 5/02, 27/32; B65B 55/00, 61/22

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X	EP,A, 356161 (MITSUI TOATSU CHEMICALS INC) 28 February 1990 (28.02.90) See page 3, lines 10-34	(1-4,6-9)
X,P	Patents Abstracts of Japan, C-792, page 46, JP,A, 2-253847 (DAINIPPON PRINTING CO LTD) 12 October 1990 (12.10.90) See abstract	(4,9)
X,P	Patents Abstracts of Japan, C-792, page 46, JP,A, 2-253846 (DAINIPPON PRINTING CO LTD) 12 October 1990 (12.10.90) See abstract	(4,9)
X,P	Derwent Abstract Accession no. 90-351289/47, Class P32, JP,A, 2-252554 (DAINIPPON PRINTING KK) 11 October 1990 (11.10.90) See abstract	(4,9)

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5 August 1991 (05.08.91)	[13 August 91] * 20 SEP 1991 (20. 09. 91)
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	ALBERT S.J. YONG

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. [ ] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 1

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.[ ] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2.[ ] Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.[ ] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 2

This International Searching Authority found multiple inventions in this international application as follows:

1.[ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.[ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.[ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 91/00145

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members
EP 356161	US 4939030 JP 2175140